

The Files - Contract 607, Task Order 1

18 March 1959

Trip Report - Thermoelectric Generator, BC-7

1. On 10 March 1959 a trip was made to the [REDACTED] Corporation, Pittsburgh, Pennsylvania, to monitor progress on Contract 607, T.O. 1, development of the thermoelectric generator, BC-7. Present for discussions were:

[REDACTED]
OC-E/R+D-EP

2. The contractor has exceeded the specified output of 3 watts for the BC-7. Tests were made at the [REDACTED] Laboratory charging a $\frac{1}{2}$ ampere-hour 12-volt nickel-cadmium battery and the following results were noted:

Open circuit voltage of battery	4 volts
Open circuit voltage of generator	36 volts
Load voltage	14 volts
Load current	380 ma
Power delivered to battery	5.32 watts
Temperature of pan bottom	305°C
Temperature of water	87°C

Another test was made with a different unit without the DC-to-DC converter using a matched load of 0.15 ohm. The following results were noted:

Open circuit voltage of generator	2.15 volts
Load voltage	1.22 volts
Power delivered to load	9.92 watts
Temperature of pan bottom	295°C
Temperature of water	84°C

Specifications called for a temperature limit of 344°C for the hot side of the generator and 100°C for the cold side. It should be noted that the temperatures in the tests were well below these specified limits.

3. The materials used in the BC-7 are zinc-antimonide and bismuth-telluride. To give an example of the high performance of these materials, consider the Seebeck coefficient. There are 25 thermocouples in the BC-7 and using the data in the test made without the DC-to-DC converter, the delta temperature was 211°C. The open circuit voltage was 215 volts, thus giving a Seebeck coefficient of 408 microvolts per degree centigrade for each thermocouple. This figure is very conservative because the temperatures measured were not junction temperatures but temperatures at the pan bottom and of the water. If the thermal losses in the pan were taken into consideration, the Seebeck coefficient would be higher. A few months ago, a Seebeck coefficient of 300 microvolts per degree centigrade was considered to be high.

4. The six prototypes being delivered have rigid construction and could be damaged by dropping or prolonged usage due to thermal expansion and contraction. This difficulty could be overcome by having an individual spring on each element of the thermocouples. This was not done on the six prototypes because it would have meant complete redesign on the frying pan due to extra $\frac{1}{2}$ inch needed in the false bottom to house the elements and springs. [REDACTED] is, however, fabricating an additional pan with the elements held in place by springs and this model will be shown to the Agency if we are interested. This design will further detract from the concealability of the unit and, unfortunately, will not resemble a frying pan. If this generator is considered for production, a different design will have to be made. Since the false bottom requires approximately $1\frac{1}{2}$ inches, a stew pot would be one means of concealability. This would allow the agent to actually cook in the unit while charging batteries. The DC-to-DC converter, in this case, would have to be a separate unit since the transistors used in it are heat sensitive and there would be no means for insulating the converter from the heat as is done with the brass handle on the frying pan.

5. It is quite evident that [REDACTED] has made many advances in the field of thermoelectricity the past six months. The BC-7 was rebuilt three times and the difference between the second model and the present model is astounding. The second model had 30 thermocouples and produced about 2 watts of power. The present model has 25 thermocouples and is capable of producing 12 watts under similar conditions of temperatures. These outputs are without the DC-to-DC converter, which is about 50% efficient. [REDACTED] stated that the DC-to-DC converters made for the BC-7 were fabricated 6 months ago and that since that time design refinement has made it possible to increase the efficiency considerably.

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